# Vehicle Energy and Alternative Fuels

Rogelio Sullivan
Managing Director
Advanced Transportation Energy Center
NC State University





## NC State Energy Research



Focus on Smart Grid research in which electric vehicles are a key component



Electric vehicle technology, charging infrastructure, and grid interface









## Research Collaborators

#### **Demonstration and Infrastructure**















# Standards and Vehicle Testing





#### **Battery Technology**







#### **Advanced Drivetrain**



**China Qianjiang Group** 



A NAVISTAR COMPANY

#### **Post Silicon Devices**

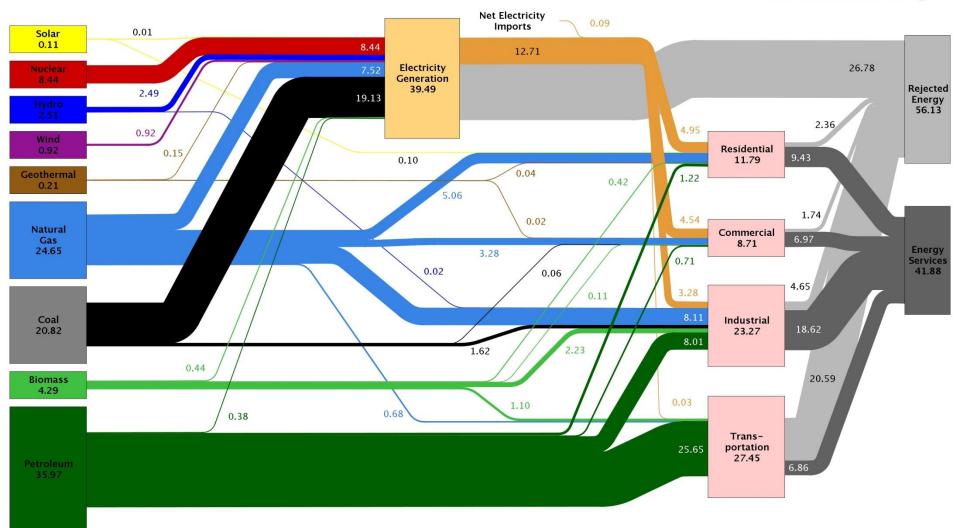






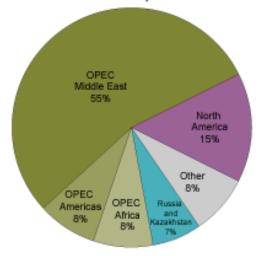
#### Estimated U.S. Energy Use in 2010: ~98.0 Quads





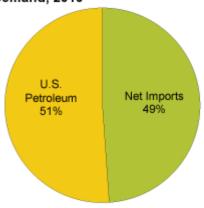
Source: LLNL 2011. Data is based on DOE/EIA-0384(2010), October 2011. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for hydro, wind, solar and geothermal in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." (see EIA report for explanation of change to geothermal in 2010). The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

#### Figure 2: Shares of Proven Oil Reserve Holders/Locations, 2010



Source: U.S. Energy Information Administration, International Energy Statistics, 2010.

#### Net Imports and Domestic Petroleum as Shares of U.S. Demand, 2010



Source: U.S. Energy Information Administration, Monthly Energy Review, Table 3.3a (April 2011), preliminary data.

# Oil Sources and Dependency

The US is only 5% of world's population but consumes 25% of all the world's oil

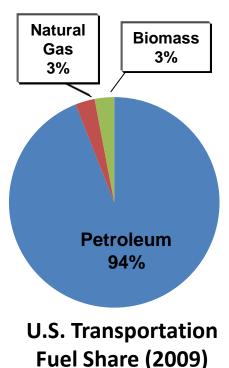


#### **2011** Sources of oil imports

- 1. Canada (25%)
- 2. Saudi Arabia (12%)
- 3. Nigeria (11%)
- 4. Venezuela (10%)
- 5. Mexico (9%)

## Oil Dependency: Transportation







- Transportation is responsible for 2/3 of our petroleum use
- On-road vehicles responsible for ~80% of transportation petroleum usage
- About 1/3 of U.S.
   GHG emissions from transportation

#### **U.S. Vehicle Market**

- About 240 million light-duty vehicles on the road
- Approximately 12M new cars & light trucks sold in 2011
- It takes 15-20 years to introduce a new technology and reach maximum market share

## Pathways for reducing oil consumption



### Reduce demand

- Reduce vehicle miles traveled
- Improve driver behavior (10-15% potential savings)
- Improve transportation system efficiency (synchronizing lights, road way improvement, roundabouts, etc.)

### 2. <u>Use more oil substitutes</u>

- Ethanol
- Biodiesel
- Propane, natural gas
- Electricity (95% domestic fueled)

## 3. <u>Improve vehicle efficiency</u>

- Hybridization
- Weight reduction
- Aerodynamics
- Engine efficiency

35 mpg CAFE by 2016

# Steady Electrification of Society

- Lighting, cooking, communication
- Consumer goods, recreation, entertainment
- Security, personal protection
- Manufacturing, industry, war/weaponry
- Cars
  - Engine management
  - Electric accessories
  - Creature comforts
  - Brake assist
  - May others

# Railroad, Ship Energy Use





Wood (steam engine) Coal (steam engine)

Heavy oil (diesel engine)

Diesel

Diesel electric

Historically, most major modes of transportation have gravitated toward electricity as the energy source.

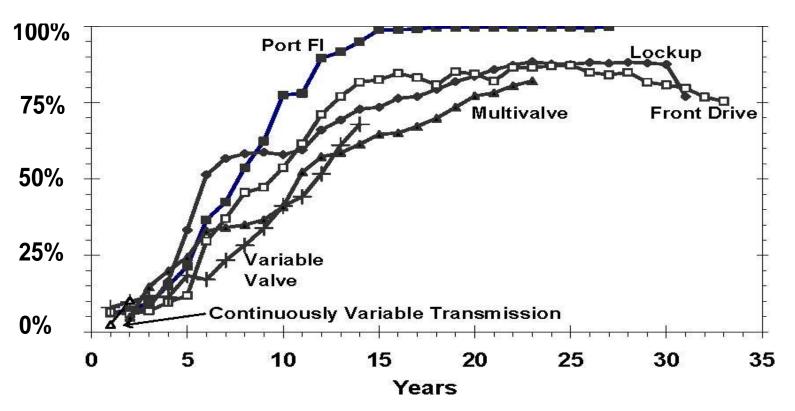
## Electric Vehicle Advantages

- Higher "system" efficiency (well to wheels)
- Greater durability
- Reduced maintenance
- Easier to control emissions
  - Large power plant emission controls
  - NC Renewable portfolio standard
- Diversify transportation energy sources
  - Currently 94% oil dependent
- Most electricity is made from domestic fuels
- Lower operating costs: 3 cents per mile for an EV v.s. 12 cents per mile for gas
- Driving enjoyment



## Change occurs slowly in vehicle market

It takes about 15 years for a technology to reach maximum penetration in new vehicle sales and another 15 years for the technology to be ubiquitous.



Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2006, EPA420-R-011, July 2006, p. 62

# Challenges for EVs

## **Major**

- ▶ Fuel prices affect consumer choice
- ▶ Consumer unpredictability
- ▶ Fear of battery life issues
- ▶ Range anxiety
- **▶** Battery cost

## **Minor**

- Power electronics and electric motors (Li and rare earth metal supply)
- Paradigm shift for utilities and consumers
- Charging and metering infrastructure

#### Round 3 for the EV!







# 2010 vehicle sales data

<u>Model</u>	% of Sales Total	
1. Ford F Series	4.5%	528,000
2. Chevy Silverado	3.2%	370,000
3. Toyota Camry .	2.9%	327,804
<b>.</b> 17. Toyota Prius	1.2%	115,065

Hybrids currently comprise approximately 1 % of all light duty vehicles on the road (2.2 M hybrids/250M total vehicles)

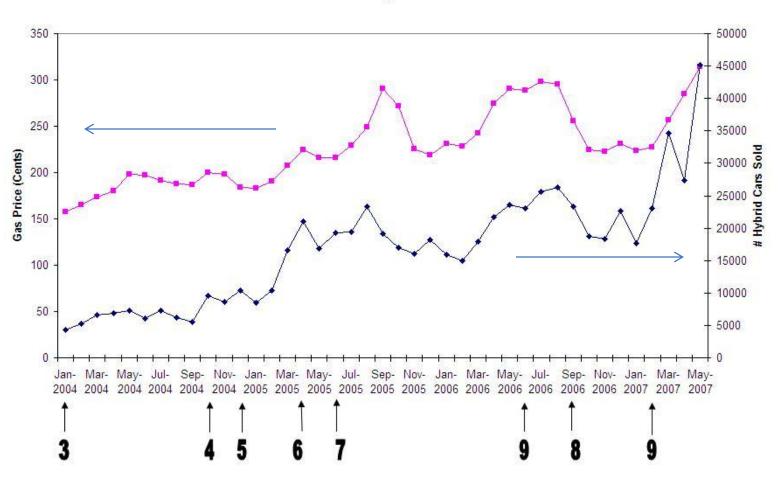




Nissan Leaf and Chevy volt cumulative sales total approximately 100,000

# Gas price affects consumer choice

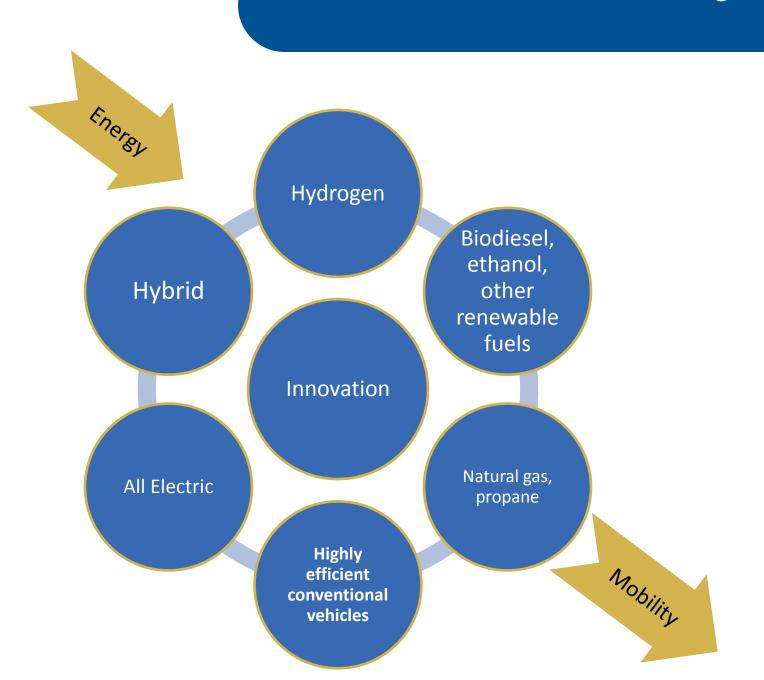
#### Gas Price vs Hybrid Car Sales



Source: Hybrid Car

Review

# Potential Future Technologies



## Local Transportation Technology Activities



- NC State research to improve batter y technology, motors, and EV Systems
- EcoCAR Vehicle competition to train the next generation of automotive engineers
- City of Raleigh deployment and demonstration projects
- EV Chargers in strategic locations
- Progress and Duke Energy demonstration programs
- Advanced Energy Nissan Leaf purchase program
- Solar Center outreach and public education

# Thank You





Rogelio Sullivan 919/513-3330 RASullivan@ncsu.edu

www.atec.ncsu.edu www.freedm.ncsu.edu